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Estimating the Population Density of Prawns by the use of Catch per Effort Data from Prawn Trawlers at Chilaw

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Introduction

The penaeid prawns of Sri Lanka from estuaries and sea are an important commercial fishery resource. This resource has been exploited over the last century or more by local fishermen using indigenous fishing gear from locally sail-driven or oar-driven fishing crafst. In more recent times (i. e. within the last 20 years) the Fisheries Research Division of the Department of Fisheries undertook surveys of the seas and lagoons of Sri Lanka with a view to ascertain whether any unexploited resources of prawns existed. Although new resources were not available in the lagoons and estuarine waters, untapped resources were located off the Old Railway Pier, Mannar in the north of the Island, a new fishery ground between Kachchitivu and Rameswaram temple, and a narrow stretch of prawn ground from Pesalai at depths of 3–5 fathom extending along the Palk Strait up to Dhanushkodi Point. A new resource was also located south-east of the Mullaithivu Light House at depths of 8–12 fathom stretching southwards to a point west of Pullimoddi. The above findings are reported in the Bulletins of the Fisheries Research Station (De Bruin, 1965, 1970, 1971).

These publications deal with the species composition, biology, distribution and abundance in the lagoons and inshore waters of Sri Lanka.

Although the total production of penaeid prawns from the lagoons and inshore waters of Sri Lanka have been estimated to be in the region of 1,000–1,500 tons per annum, (De Bruin, unpublished) these figures were based mainly on eye estimates of catches made over a long period of time from the main productive centres of the Island. The prawn fisheries at Negombo and Chilaw are two of the most productive centres and it seemed advisable therefore to make a record of the catches in this region in order to observe, firstly, the productivity of these centres and secondly the effect of the intensity of fishing on the population density of the penaeid prawns. This paper outlines the result of work carried out at Chilaw during the period 13.1.77 to 1.3.77, and gives an estimate of the population density of the different species of prawns in the fishing grounds off Chilaw. This particular period was from earlier experience found to be the time at which the population density is lowest.

Prawn Trawling at Chilaw

Prawn trawling at Chilaw has been in existence for the last few hundred of years. Before the introduction of 3½ ton mechanised boats, outrigger canoes with sail were engaged in prawn trawling and their operations were confined to the banks lying between Karukapone and Mahamade. The original net used to capture prawns consisted of a square mouth 11 ft. × 11 ft. and tapering as a cone for a length of 3½ ft. The original net consisted of cotton fibre. The mesh size was uniform and measured 5/8 inches when stretched.

Fishing for prawns in this region, off the 28-foot mechanised boat, powered by inboat diesel engines, commenced around 1962. The operations of mechanised boats were hampered by frequent sand-bar formation at the mouth of the Chilaw lagoon, which prevented easy access of the boats to

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the traditional fishing ground, and also the consumption of fuel during trawling operations tended to be a limiting factor. However, a continued effort with the mecahnised boats showed that it was more lucrative than operating from the traditional craft, and continued trawling was assured due to its independence of vagaries in the wind and season. The catch also increased considerably as more ground could be trawled using the mechanised powered craft. Trawling takes place on the bank between Karukapone and Mattakkotuwa, measuring 12 miles by length and 1 mile by breadth, leaving some patches in Karukapone and Ambakanthawila, where submerged rocks are found at the bottom (Figure 1).

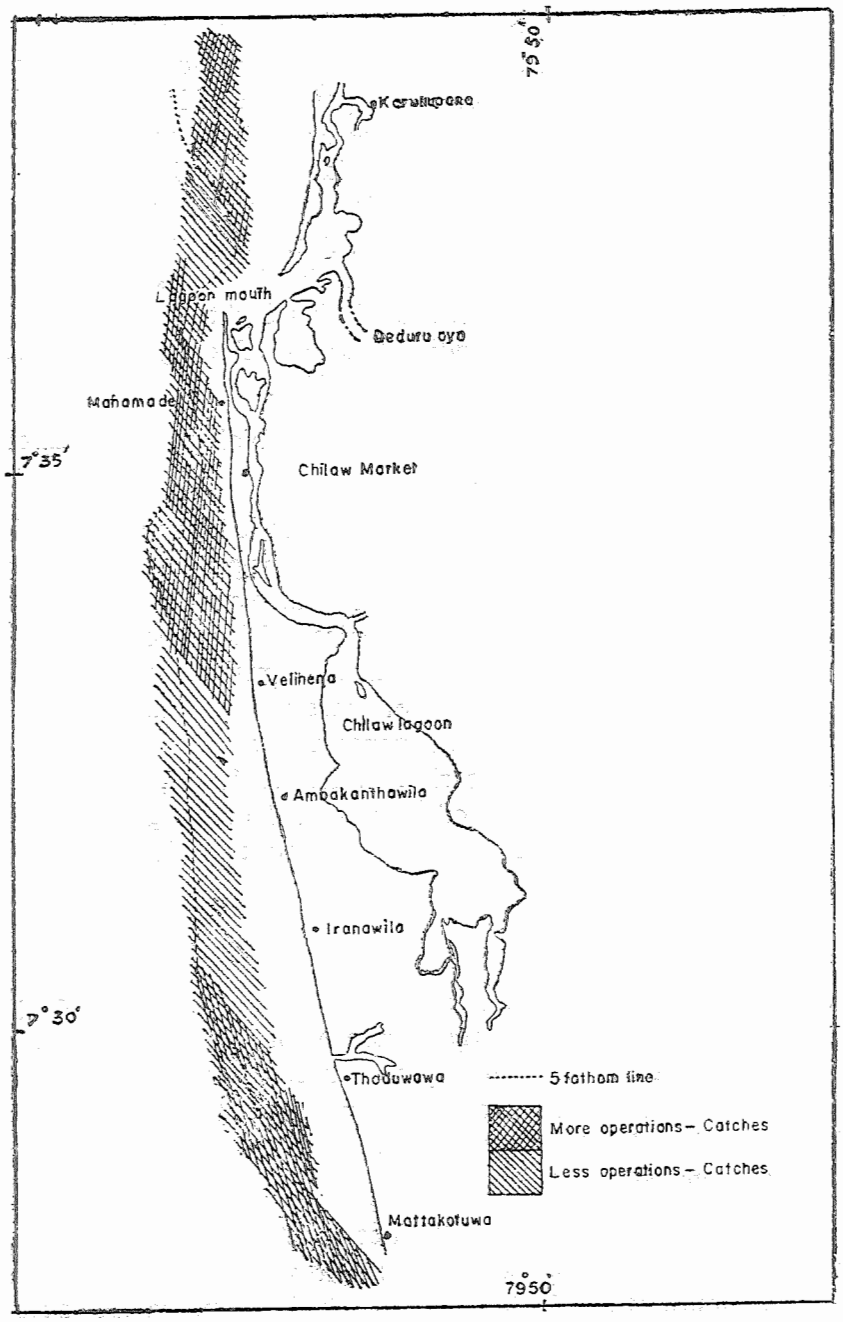

Fig. 1—The Chilaw Fishing Grounds.

The bottom of the trawling grounds consist of mud, mud and coarse sand, mud and fine sand and fine mud. It was observed that the biggest catches were made on grounds consisting of very fine mud.

The trawl net used by the mechanised boat was of modified design. Its mouth was widened, and the net narrowed down from mouth to cod end. Trawling starts just before sun-rise, and the trawlers return to Chilaw market at any time between 10.00 a.m. and 3.00 p.m. It was observed that a trawler would do an average of four trawls, each operation lasting an average period of 90 minutes and between two consecutive hauls there was a delay of an average period of 12 minutes.

The catch is brought ashore at the end of operations and sorted out into the following categories :—

(*a*) The tiny prawn (*Metapenaeus dobsoni, Parapeneopsis stylifera, Parapeneopsis coromandelica, Parapeneopsis cornuta, Metapenaeus monoceros, Parapeneopsis uncta, Metapenaeus affinis, Metapenaeus ensis, Caridian species, Trachypeneus species, Metapenaeopsis hilarulus, Metapenaeus burkenroadi, and* Smaller sizes of *Penaeus indicus* and *Penaeus semisulcatus*, etc.)

(*b*) The medium and larger sized prawns (*Penaeus indicus, Penaeus semisulcatus, Penaeus monodon*)

(*c*) The fish.—The tiny prawns and the fish are sold in small baskets by auction at the market. A basketful of tiny prawns weighed roughly 12 pounds. Medium and large prawns are graded into three, according to their sizes and are sold to businessmen. During the study period, a basketful of tiny prawns fetched an average price of rupees twenty-five and among the medium and large prawns the first grade (1–24 head on pieces per pound) fetched rupees twenty seven per pound, second grade (25–34 head on, pieces per pound) fetched rupees twelve per pound and the third grade (35–55 head on, pieces per pound) fetched rupees six per pound.

Methods and Material

(*a*) *Record of Landing.*—Each trawler was given a number in accordance with its landing time A systematic random sample of numbers was drawn daily, and the fishermen in the selected numbered trawler was interviewed. The weight of the catch from each of the trawlers was recorded in detail such as the weight of medium and large prawns, the weight of tiny prawns and the weight of fish. The number of prawns in a pound of large and medium sized of prawns was counted, and the average weight of each large and medium prawn was estimated. The weight of medium and large prawns from a trawler was estimated by counting the number of pieces of large prawns and medium prawns in its catch, knowing the average weight of each large and medium prawn. The weight of tiny prawns landed by a trawler was estimated from the number of small baskets of tiny prawns removed from the trawler having estimated the average weight of a small basketful of tiny prawns. Exact weighing of prawns was not possible due to lack of co-operation from the fishermen.

The horse-power of the engines was found to be in the range of 28–32, and the average trawling speed was 1.2 knots. Dimensions of the trawl nets and the manner in which they were constructed were similar. Upper and lower lobe of the net when stretched measured 37 ft. to 42 ft. The net

narrowed down to 3ft.—4ft. at the cod-end. The nets were made of nylon 6.6 twine, with the cod-end made of kuralon. The stretched mesh sizes of the nets at different times of the study period are given below :—

Date	*Mouth*	*Belly*	*Cod-end*
13.1.77 – 31.1.77	22 mm(3 ply)	17 mm (3 ply)	10 mm (9 ply)
1.2.77 – 1.3.77	30 mm(6 ply)	14 mm (3 ply)	10 mm (9 ply)

The mesh sizes of the trawls varied during the periods 13.1.77–31.1.77 and 1.2.77–1.3.77. This was due to the fact that the fishermen believed that the larger size meshed nets used in the second period were more effective in capturing the fish that were present on the bank during this period as the prawn potential on the ground had now decreased considerably

Since there was very little variation in the sizes of the mechanised boats horse-power of the engines, size of the nets used in the operations as well as speed and duration of tow it can be safely assumed that the fishing units as indicative of fishing intensity could be regarded for the purpose of statistical analysis as homogeneous.

If the statistical analysis was made on the observed catches of mixed prawns (i.e. mixed sizes) the coefficient of variation was high. It was observed that this high variability was due to irregularity in the presence of large size prawn in different boats under consideration. However if the catches of the tiny prawns were compared there appeared to be very little variation between boats. Hence the daily total catch of tiny prawns and medium and large prawns were analysed independently.

(*b*) *Fishing Effort.*—Particulars such as trawling area, number of hauls, time of fishing, etc., were recorded from the sampled crafts. Effective fishing time was computed for each trawler having deducted the steaming and hauling times Coefficient of variation values of the sample efforts were observed to be small Table (1) shows this. The daily total effort was computed from the sample values.

Fishing success Estimates (*De-Lury method*).—The average catch per unit effort is compared with the accumulated catch. For this purpose the catch per unit effort is plotted against the accumulated catch. A downward trend in catch per unit effort suggests that the population is being reduced as a result of fishing. The extrapolation of the trend line for the catch per unit effort to the accumulated catch scale provides an estimate of the number of prawns, present on the grounds, at the time the downward trend began

Examination of the previous years' catch records suggested that an estimate of population size might be obtained, since the catch per unit effort values were declining. The most promising period in the year was between January 13 and March 1.

Records covering fishing from January 13 to March 1 are given in Table (2), for *M. dobsoni P. stylifera* and *P. coromandelica* (combined), *P. cornuta, P. monodon, P. semisulcatus, P. indicus P. uncta, M. monoceros,* respectively, include total daily catch, total daily effort, daily catch per effort, $C_{(t)}$, and cumulative catch $A_{(t)}$ found by accumulating the daily values of total catch.

Daily values of catch per effort are plotted against cumulative catch for each species. A test of linearity was made. To do this the 'F' test was used (Dixon and Massey 1957) and the average catch per one hour effort values were grouped for arbitrary 2,000 pound, 500 pound, 25 pound, 25

pound, 200 pound, 500 pound, 100 pound groupings of accumulated catch for *M. dobsoni*, *P. stylifera* and *P. coromandelica*, *P cornuta*, *P. monodon*, *P. semisulcatus*, *P. indicus*, *M. monoceros*, *P. uncta* respectively. The values obtained are given in Table 3.

M. dobsoni.—From Table (3),

$$F = \frac{1.24000}{0.56842} = 2.181, \text{ with } V_1 = 9,\ V_2 = 26$$ As the F value is found to be less than 2.26, it is not significant at 5% level. Hence the relationship could be given by a linear equation. The linear equation obtained by the least square method is—

$$C_{(t)} = 5.439612 - 0.000257\ A_{(t)}$$

$$\text{Initial population of } M.\ dobsoni\ A_{(o)} = \frac{KA_{(o)}}{K} = \frac{5.439612}{0.000257_{(C)}} = 21{,}166 \text{ pounds}$$

K = Catchability = 0.000257.

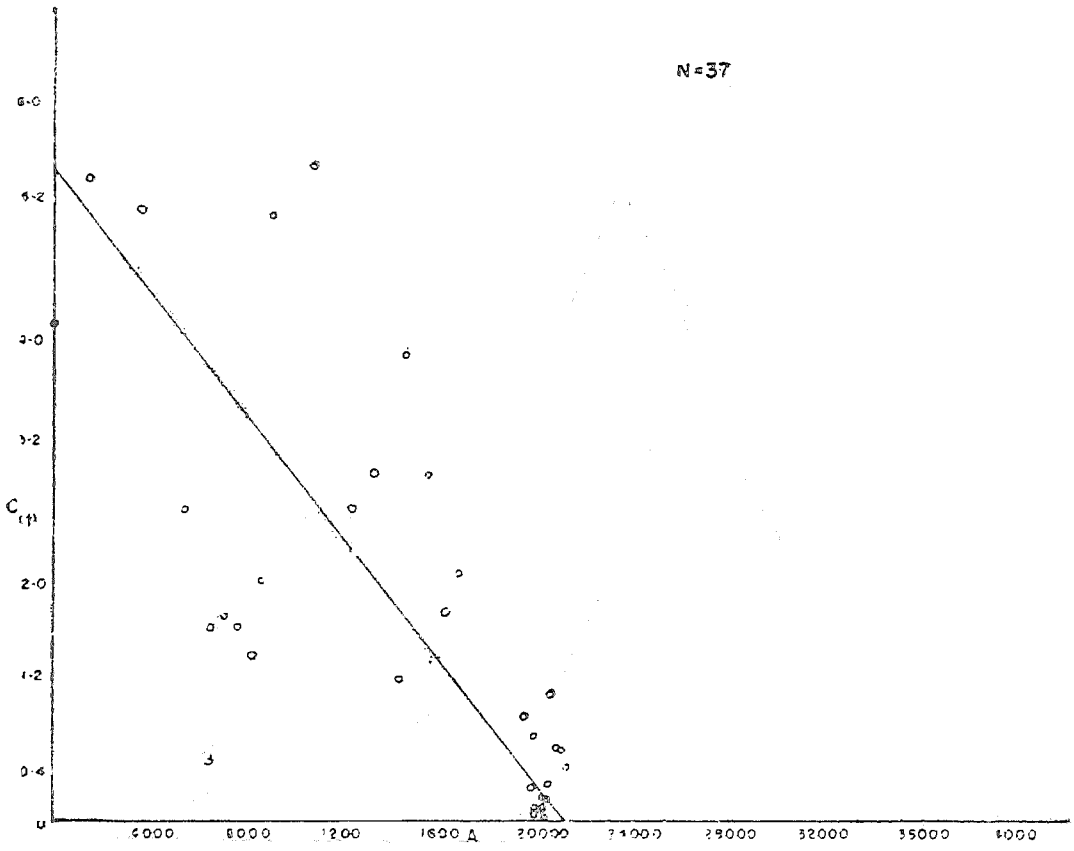

Fig. 2.—Relationship of catch per effort C(t), to accumulated catch, A(t), of *Metapenaeus dobsoni* for the period January 13th to March 1st, 1977 (N=37 days).

The daily total catches on 4th, 5th and 8th of February were found to be much higher than those made on the other days between 13th January to 1st March and were probably due to immigration of larger sizes of *M. dobsoni* (8.0–10.0 cm. total length) from other grounds or from areas of the same ground which are not accessible to the trawlers. These were completely fished in four days with the remainder probably migrating to the other grounds or dying off. The extraordinarily high catches made on the 4th, 5th and 8th of February have been excluded in the calculations designed to determine the population size.

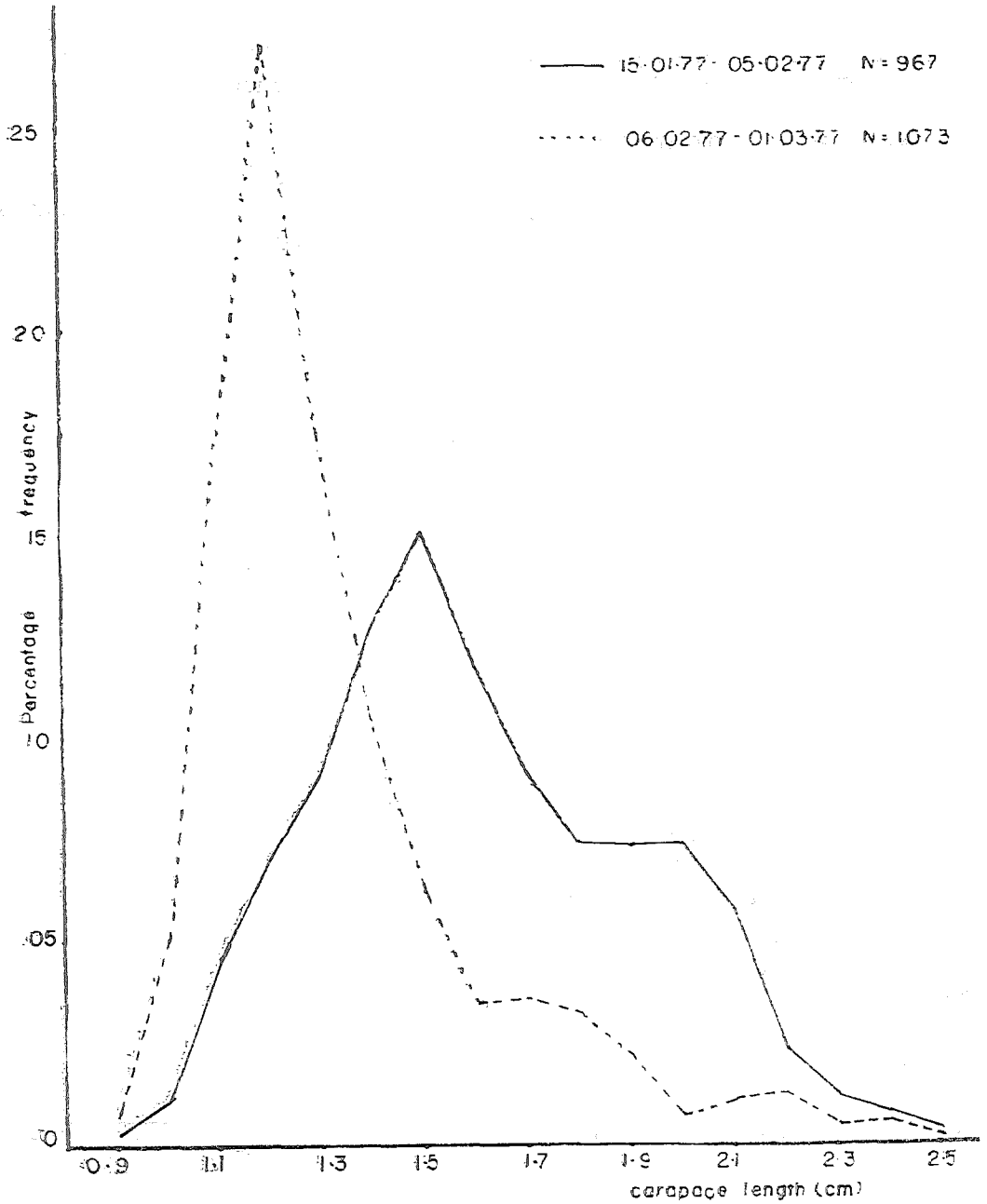

Fig. 3.—Size frequency distribution of *Metapenaeus dobsoni* landed during January 13th to March 1st, 1977.

The length frequency graph, of *M. dobsoni is* shown in Fig. 3. There is a reduction in larger sizes (Carapace length > 1.4 cm.) with a steep increase in medium sizes (carapace length 1.0–1.3 cm) in February. This suggest that due to heavy fishing, larger sizes of prawns are more vulnerable to the trawl net with a particular mesh size and were being removed in larger quantities from the fishing ground and there was no substantial amount of immigrant prawns other than those caught on 4th, 5th and 8th of February. There also does not seem to be new recruitment to the population from the estuarine waters.

P. stylifera and P. coromandelica.—These two species were considered together, Table (2), as we encountered some difficulties in separating out those *P. stylifera* whose telsons were broken from *P. coromandelica.*

From Table (3), $F = \frac{0.10550}{0.12569} = 0.839$ with $V_1 = 10$, $V_2 = 29$.

As the F value is found to be less than 2.18, it is not significant at 5% level. Hence the relationship is linear. The equation obtained by the least square method is —

$$C_{(t)} \quad 0.861708 - 0.000120\, A_{(t)}$$

Initial population $A_{(o)}$, of *P. stylifera* and *P. coromandelica* could be estimated —

$$A_{(o)} = \frac{K\, A_{(o)}}{K} = \frac{0.861708}{0.000120} = 7181 \text{ pounds}$$

K = Catchability = 0.000120.

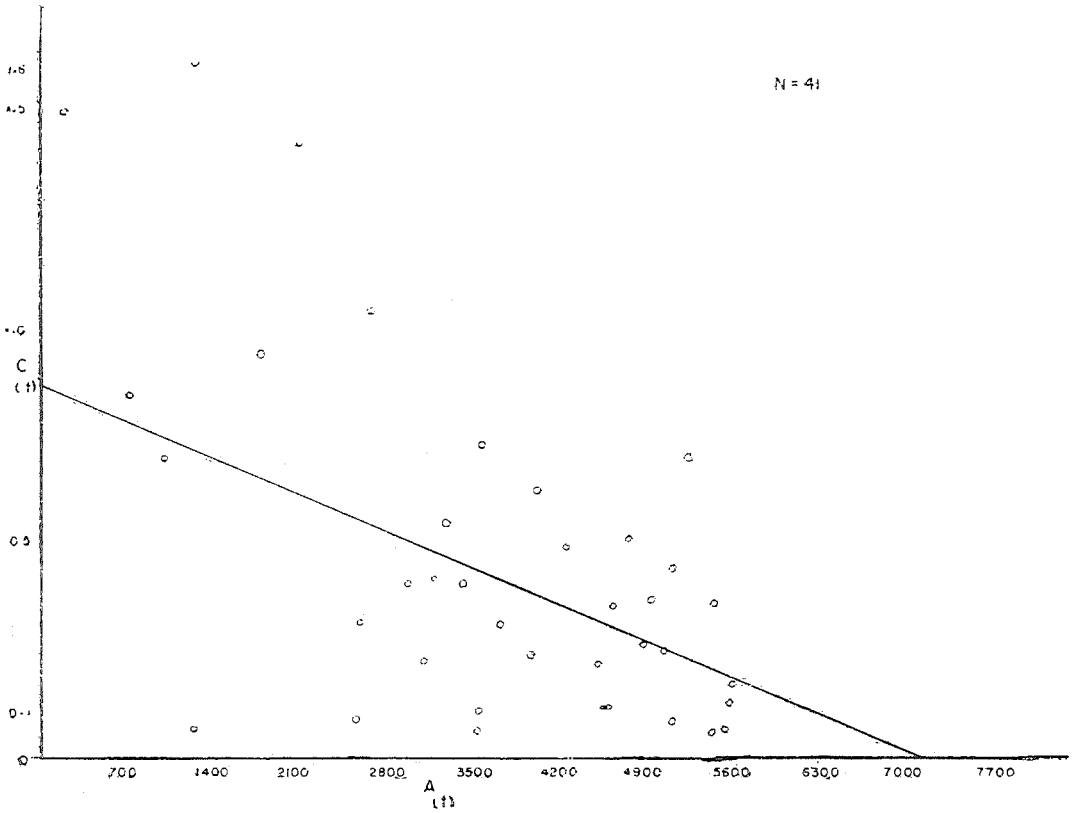

Fig. 4.—Relationship of catch per effort C(t), to accumulated catch, A(t), of *Parap. stylifera* and *Parap. coromandelica* for the period January 13th to March 1st 1977. (N=41 days)

The length frequency curves of *P. stylifera* and *P. coromandelica* show reduction in the percentage of larger sizes of prawn with a comparative increase in medium sizes of prawn in February, for the same reason mentioned under *M. dobsoni*. In the case of *P. coromandelica* percentage frequencies of the sizes with Carapace length < 1.3 cm were noticeably higher in February than in January, which may suggest that there was substantial amount of recruitment.

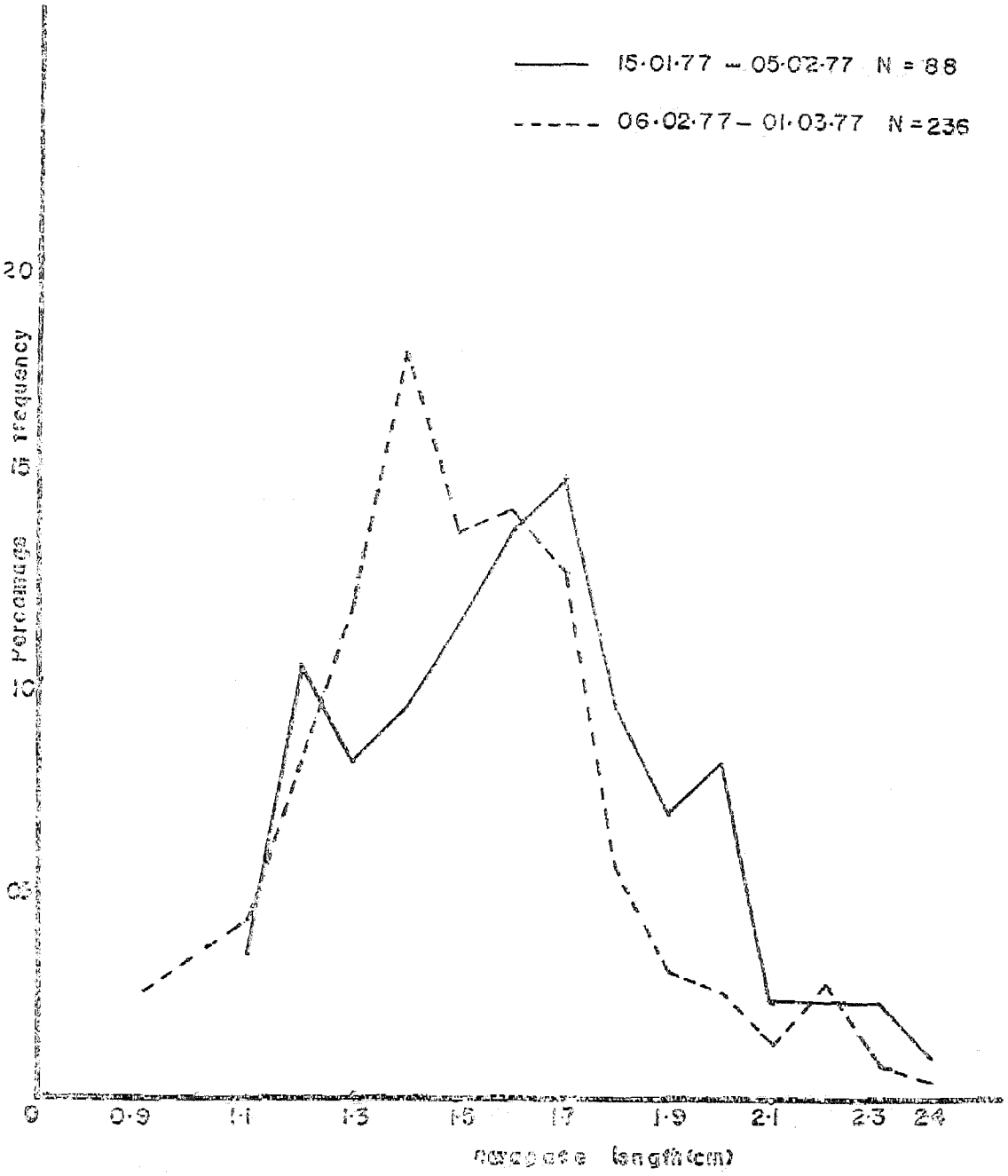

Fig. 5.—Size frequency distribution of *Parap. stylifera* landed during January 13th to March 1st, 1977.

Although it is not correct to assume that the catch per effort is proportional to the stock present under those conditions, author assumed it to be so for the reason that *P. stylifera* and *P. coromandelica* were treated the same when recording the catch, where the percentage of *P. coromandelica* in the daily total catch was observed to be small (<13 per cent).

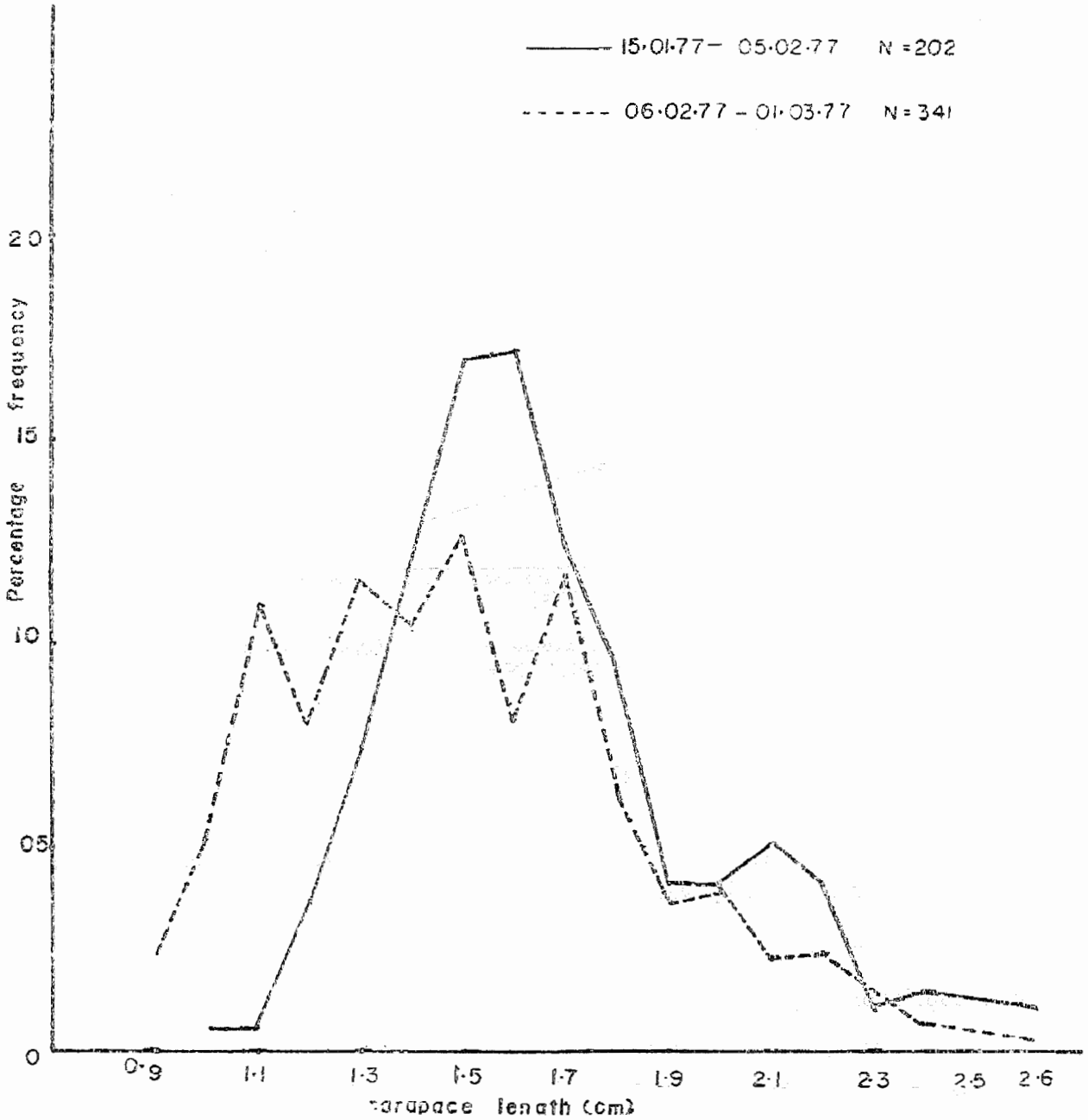

Fig. 6.—Size frequency distribution of *Parap. coromandelica* landed during January 13th to March 1st, 1977.

P. cornuta.—Data taken between 13th January and 8th February were considered, (Table 2). After this period the catch per effort was increasing or fluctuating. There was no record of catch on the 4th and 5th of February. This was because of the small samples taken on these days, when the

catches were very high, and dominated by immigrant *M. dobsoni*. On each of these dates 6 pounds was added to the accumulated catch, since this was the average quantity of daily catch landed immediately before these dates.

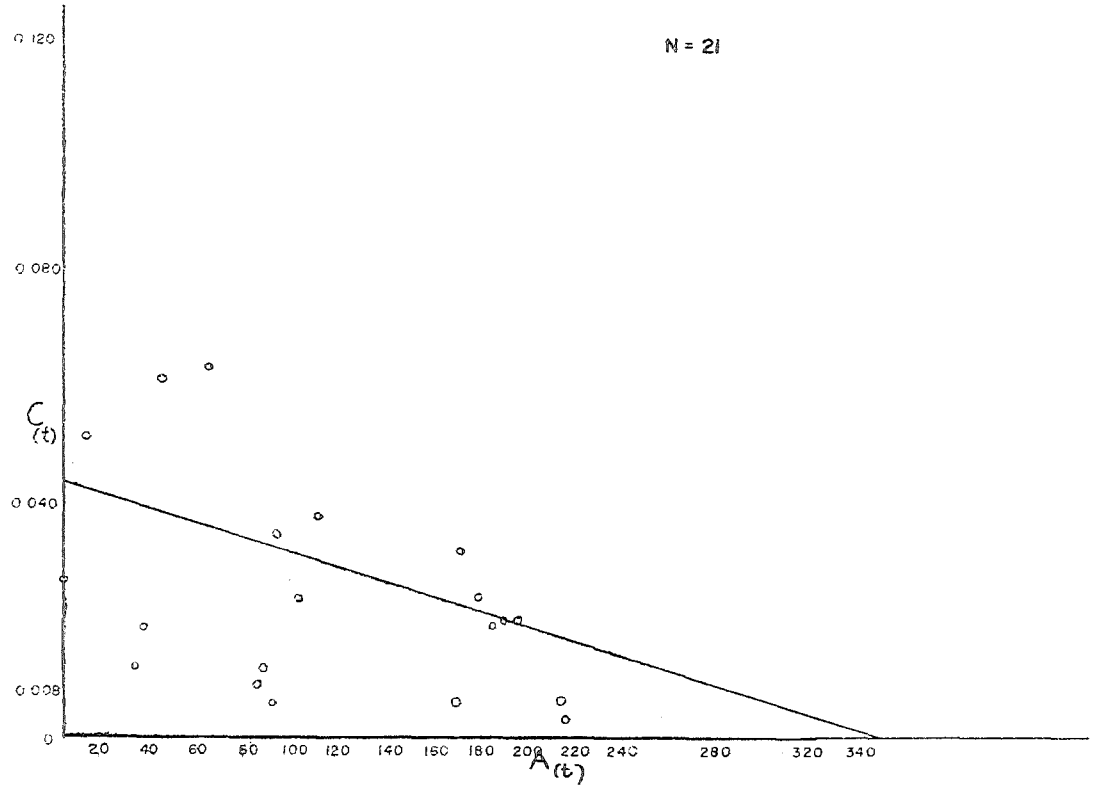

Fig. 7.—Relationship of catch per effort C(t), to accumulated catch, A(t), of *Parap. cornuta* for the period January 13th to February 8th, 1977 (N=21days).

$$\text{From Table 3, } F = \frac{0.00112}{0.00078} = 1.436,\ V_1 = 6,\ V_2 = 13.$$

Since the value of F is less than 2.92, it is not significant at 5% level. As such the relationship is linear. The equation obtained by least square method is —

$$C_{(t)} = 0.044281 - 0.000127\, A_{(t)}.$$

Initial population $A_{(o)}$ of *P. cornuta* could be calculated

$$A_{(o)} = \frac{KA_{(o)}}{K} = \frac{0.044281}{0.000127} = 349 \text{ pounds}$$

$$K = \text{Catchability} = 0.000127.$$

Figure (8) shows the length frequency polygon of *P. cornuta*. The graph is uneven because of the small number of measurements taken, hence it is not a true representation of the population. However a study of the length group frequency graphs indicates the reduction of larger sizes of prawn

(carapace length>1.3 cm.) in the second half of the period (17.12.77–1.3.77) with substantial increases in medium sizes (carapace length 1.1–1.2 cm) and small sizes (Carapace length<1.0 cm). The reduction of larger sizes was due to intense fishing and possible emigration of left over population from the ground, and the increase in smaller sizes at the second period was due to heavy recruitment. This contributed to the fluctuation of the daily total catch after February 8th.

Other Species of Prawns

For each of *P. monodon*, *P. semisulcatus*, *P. indicus*, *M. monoceros* and *P. uncta* a linear relationship could not be obtained between catch per effort and accumulated catch, since either the catch rate

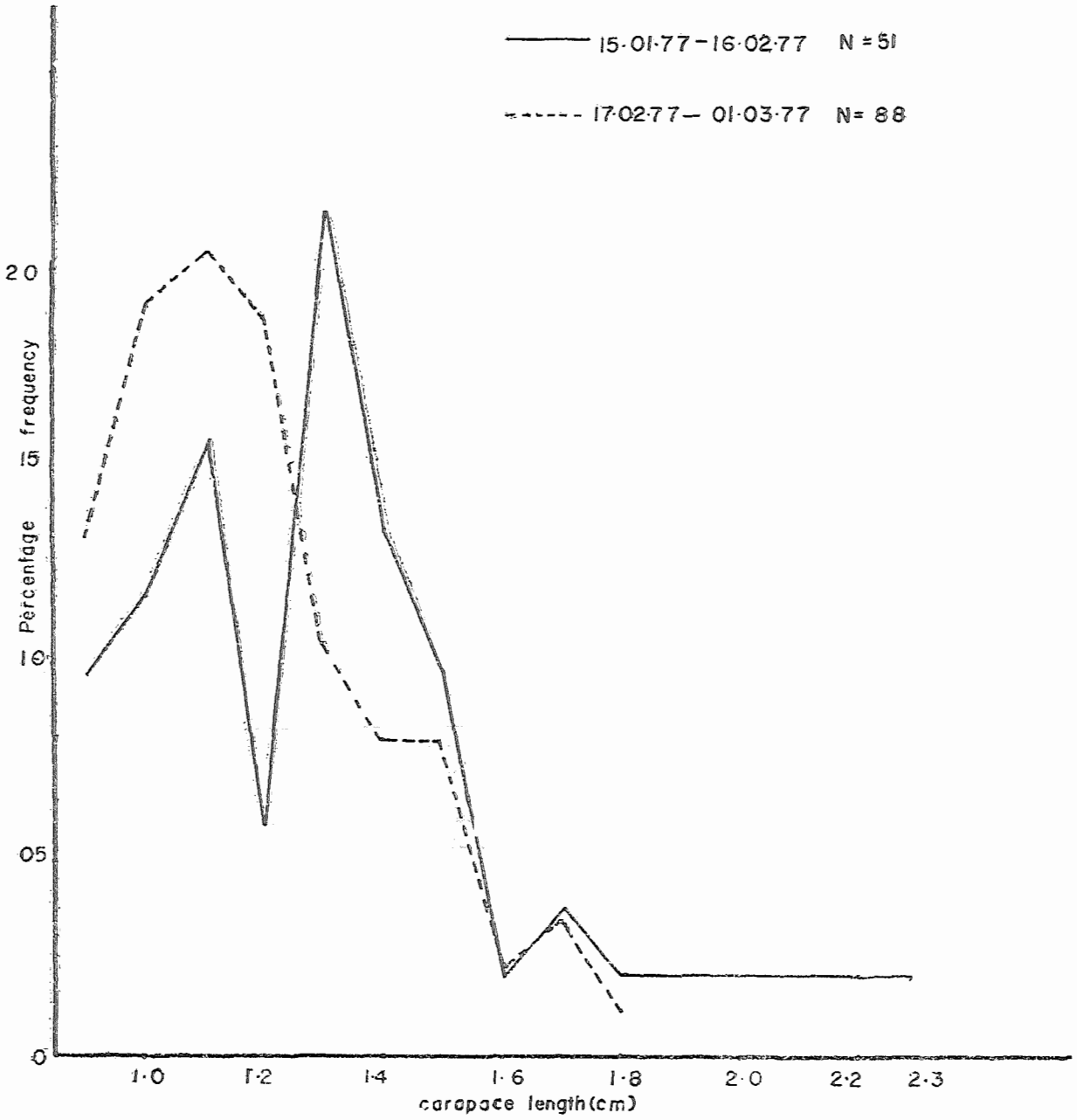

Fig. 8.—Size frequency distribution of *Parap. cornuta* landed during January 13th to March 1st, 1977.

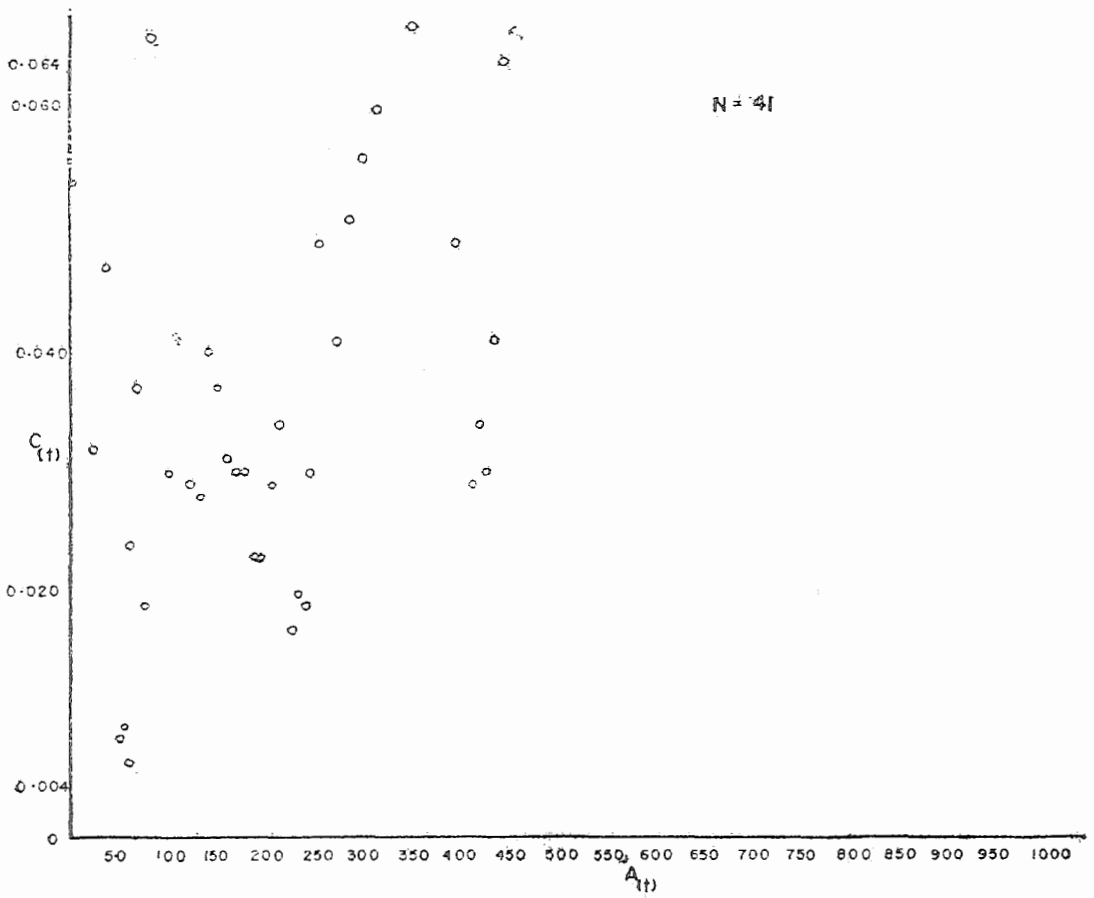

Fig. 9.—Relationship of catch per effort C(t), to accumulated catch, A(t), of *Penaeus monodon* for the period of January 13th to March 1st, 1977 (N=41 days).

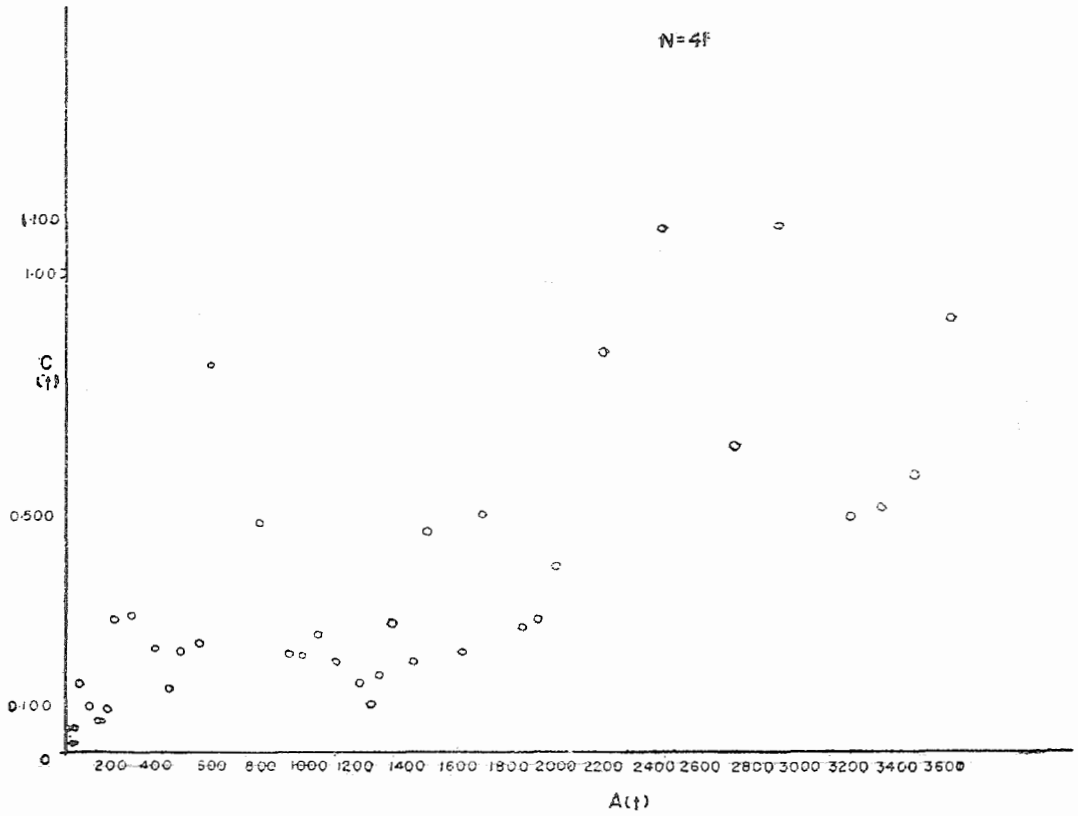

Fig. 10.—Relationship of catch per effort C(t), to accumulated catch, A(t), of *Penaeus semisulcatus* for the period January 13th to March 1st, 1977. (N=41 days)

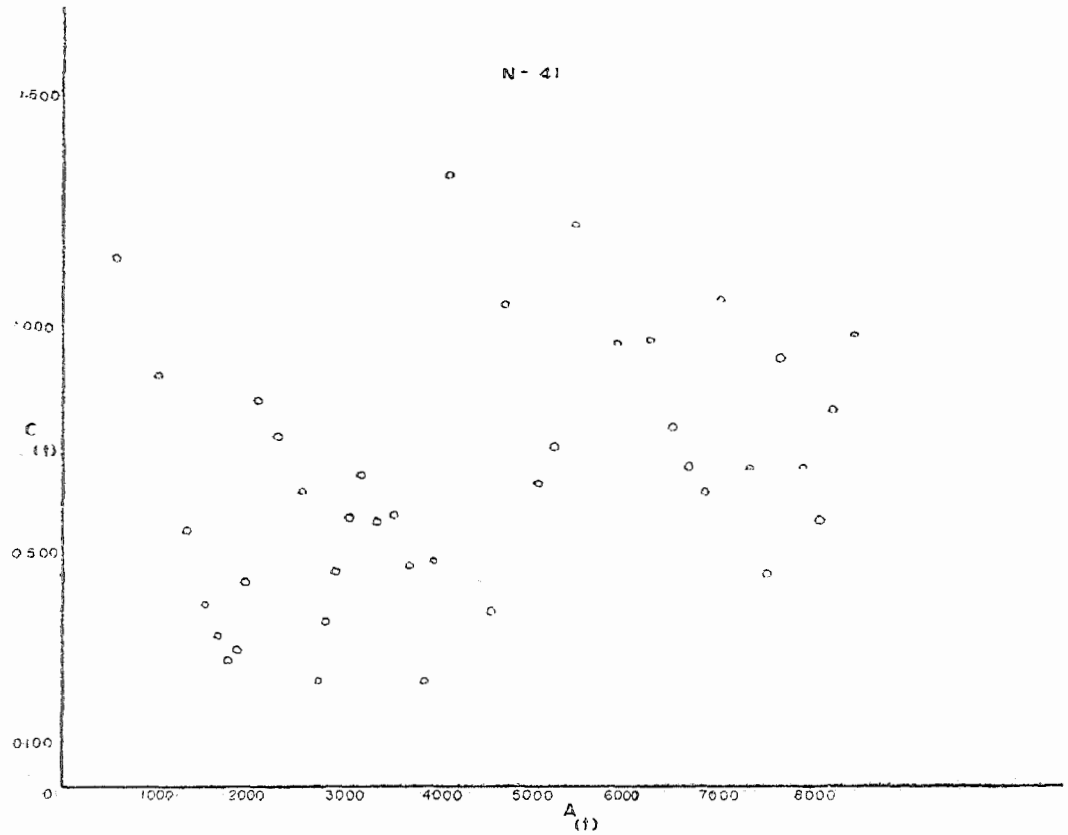

Fig. 11.—Relationship of catch per effort C(t), to accumulated catch, A(t), of *Penaeus indicus* for the period January 13th to March 1st, 1977 (N=41 days).

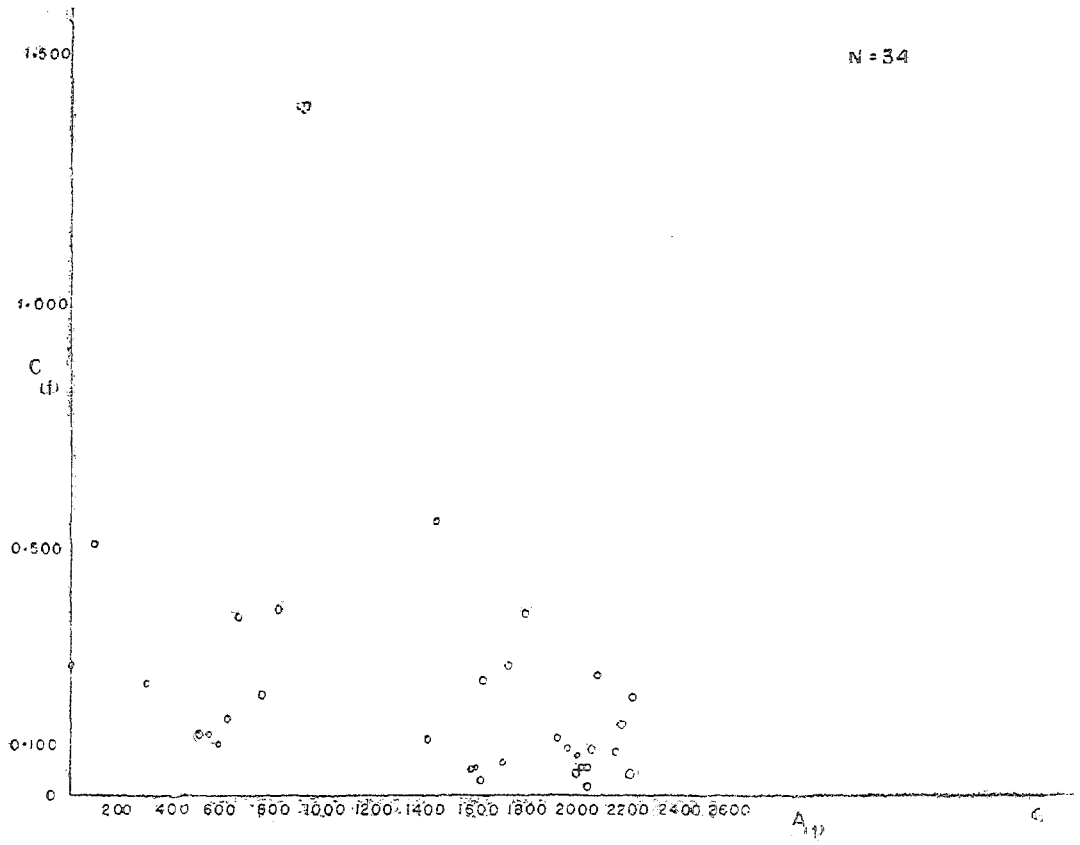

Fig. 12.—Relationship of catch per effort C(t), to accumulated catch, A(t). of *Metapenaeus monoceros* for the period January 13th to March 1st, 1977. (N = 34 days).

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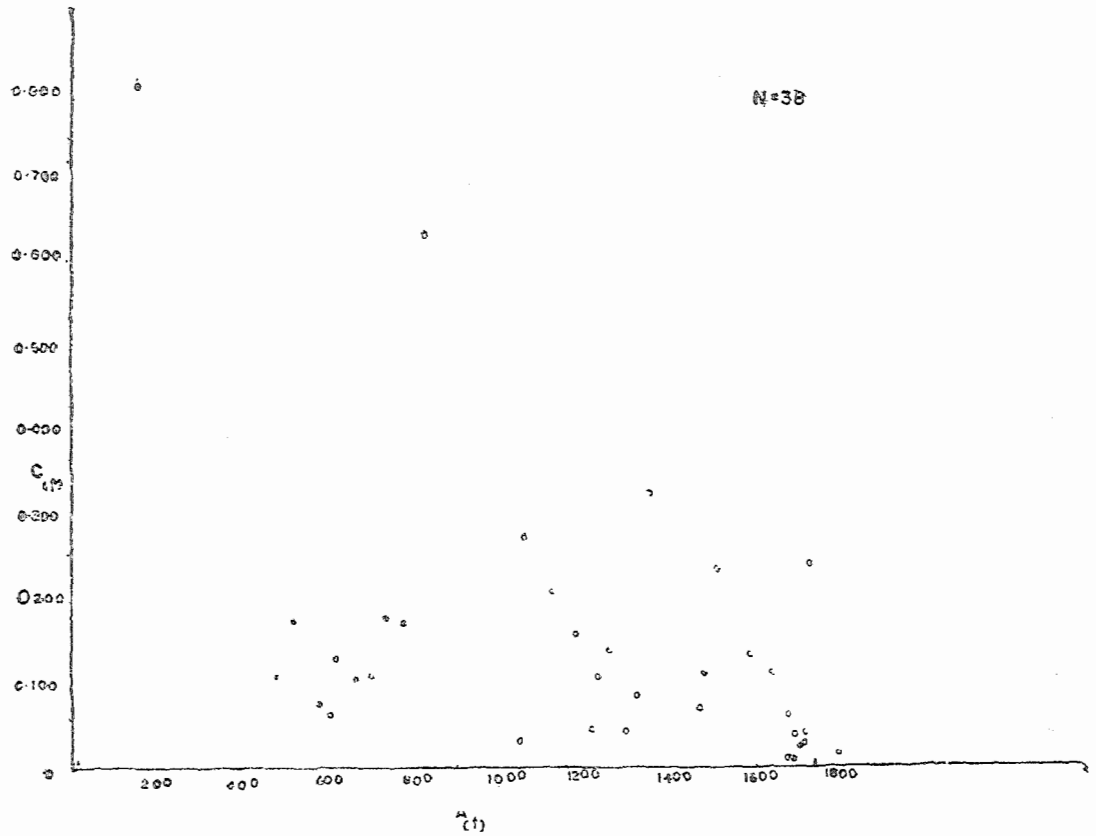

Fig. 13.—Relationship of catch per effort C(t), to accumulated catch, A(t), of *Parap. uncta* for the period January 13th to March 1st, 1977. (N = 38 days).

was increasing or fluctuating hence the population estimate of these species could not be obtained. Their 'F' values calculated from Table (3) are given below. All the values are significant at 5% level.

	Estimated		*F*	V_1	V_2	5% *value*
P. monodon	$\frac{0.00056}{0.00013}$	=	4.308	16	23	2.04 – 2.13
P. semisulcatus	$\frac{0.07085}{0.01890}$	=	3.749	16	23	2.04 – 2.13
P. Indicus	$\frac{0.17913}{0.03868}$	=	4.631	15	24	2.11
M. monoceros	$\frac{0.12023}{0.01226}$	=	9.807	13	19	2.23 – 2.31
P. uncta	$\frac{0.04723}{0.00552}$	=	8.556	13	23	2.13 – 2.20

Catch rate of *P. monodon* (Figure 9), *P. semisulcatus* (Figure 10) were observed to be increasing in the latter part of the period and the catch rate of *P. indicus* (Figure 11) was observed to be stabilised at a higher level at the latter part of the period, whereas the catch rates of *M. monoceros* (Figure 12) and *P. uncta* (Figure 13) were fluctuating more or less at constant level.

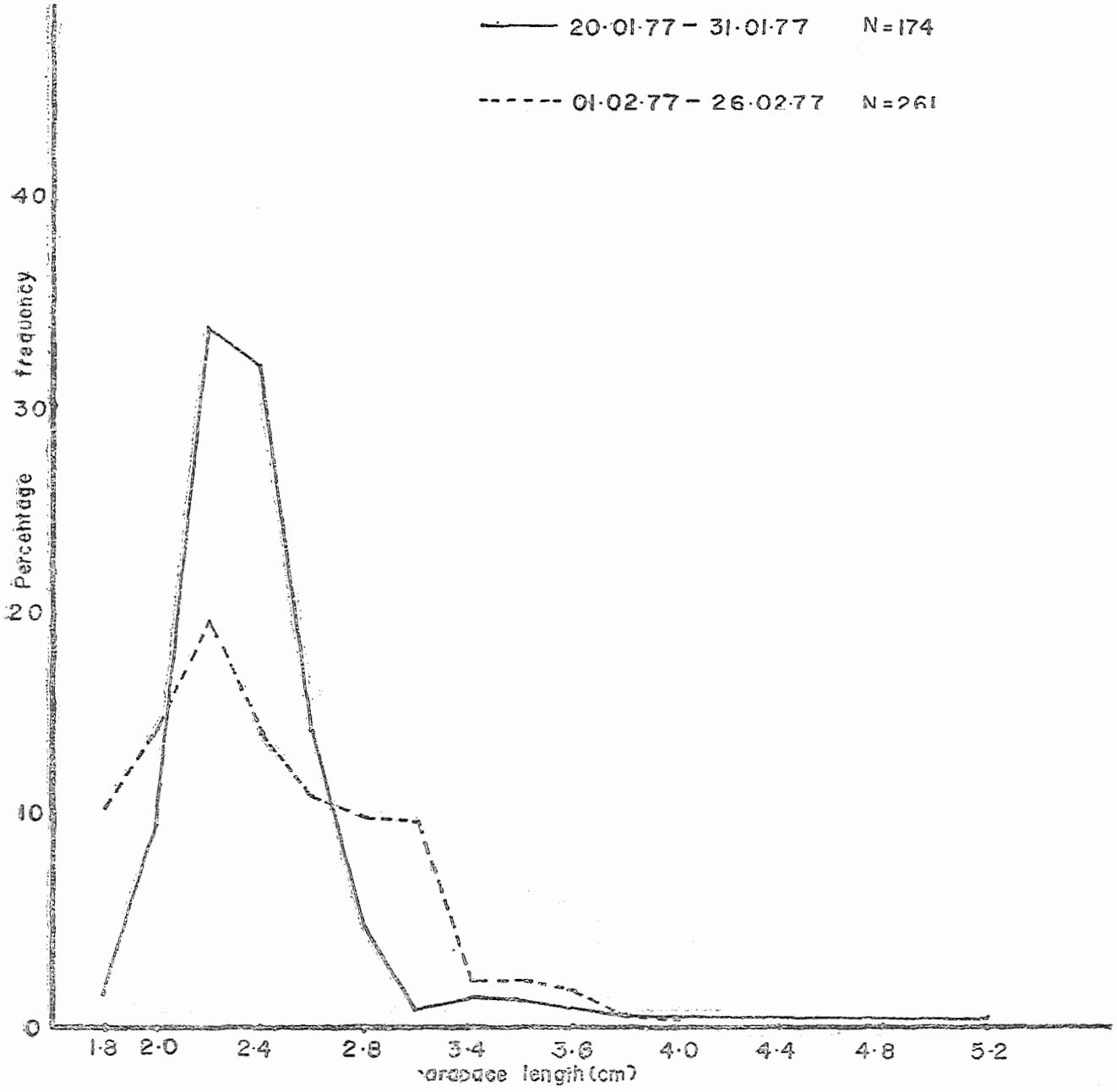

Fig. 14.—Size frequency distribution of *Penaeus indicus* landed during January 13th to March 1st, 1977.

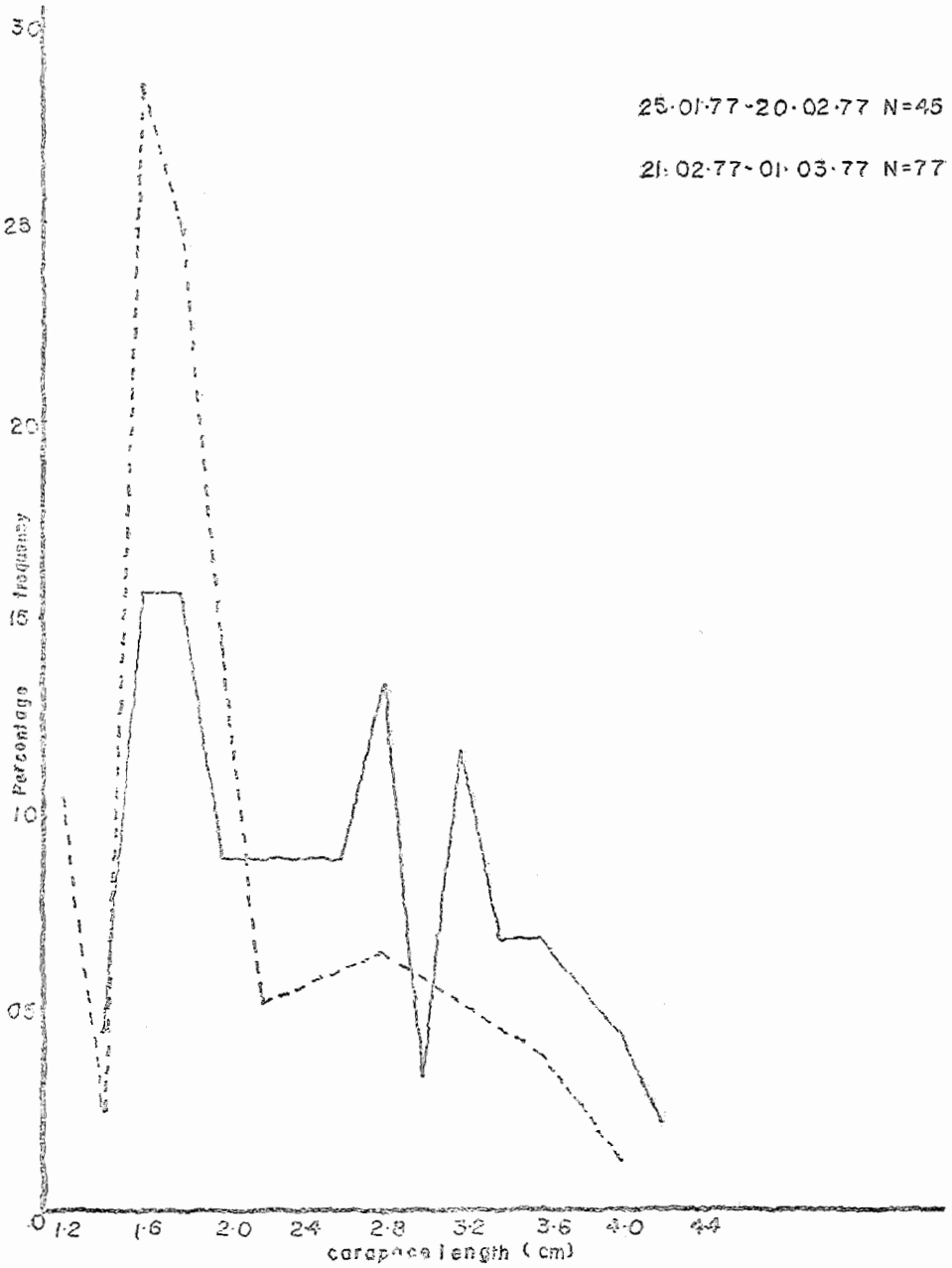

Fig. 15.—Size frequency distribution of *Penaeus semisulcatus* landed during January 13th to March 1st, 1977.

Figure 14 shows that the frequencies of larger sizes of *P. indicus* (carapace length>2.8 cm) were increased with a reduction in medium sizes (carapace length 2.2 cm–2.6 cm) and increase in smaller sizes (carapace length<2 cm) in February, whereas the frequencies of medium sizes of *P.indicus* were higher in January. This suggested heavy recruitment of small catchable sizes and probable migration of larger sizes to the trawl ground during latter part of the survey.

Length frequency curves for *P. monodon, M. monoceros and P. uncta* were not given, as the number of length measurements taken were too few. From Figure (15) it was observed that smaller sizes of *P. semisulcatus* (carapace length<1.6 cm.) were caught in greater quantities at the latter part of the study period which suggested heavy recruitment, resulting in the increase in catch rate at the latter part of the study period.

Species Composition

Table (4) gives sixteen species of prawns encountered in Chilaw sea. Their relative abundance is given in terms of total pounds of each species caught by the trawlers for the period 13.1.77–1.3.77.

Conclusion

A linear relationship between catch per effort and accumulated catch could be obtained for *M. dobsoni P. stylifera* and *P. coromandelica* (both taken together), *P. cornuta* and hence their stock at the start of our survey could be estimated and the values are given below :—

M. dobsoni = 21,166 pounds

P. stylifera and *P. coromandelica* = 7181 pounds

P. cornuta = 349 pounds.

The fact that a linear relationship could be obtained for each of the above species suggestet that emigration and natural mortality were to a certain extent balanced by immigration. An estimate which is not influenced by emigration, immigration and natural mortality could be made if we hand carried out tagging experiment simultaneously which involves much labour, co-operation from fishermen and heavy expenditure. Any how the above population estimates may be taken as approximate figures, for the reason that necessary precautions were taken to reduce the effect of immigration and recruitment on the final estimate.

Summary.—(1) Fishing success method was employed to estimate the population of different species of prawns in Chilaw sea.

(2) The plot for the January 13 to March 1, 1977 period of catch per unit of effort against accumulated catch for *M. dobsoni, P. stylifera* and *P. coromandelica* and the plot for the January 13 to February 8, 1977 period of catch per unit of effort against accumulated catch for *P. cornuta,* appeared to be straight lines As such their population could be estimated and their stock values at the start of our survey are given below :—

M. dobsoni = 21,166 pounds

P. stylifera and *P. coromandelica* = 7,181 pounds

P. cornuta = 349 pounds.

(3) Between 4th February and 8th February, 39,782 pounds of immigrant *M. dobsoni* (as estimated) were fished, which increased the estimate of *M. dobsoni* on the fishing ground for the study period to 60,948 pounds.

(4) The plot of catch per unit of effort against accumulated catch for the species *P. monodon P. semisulcatus, P. indicus, M. monoceros, P. uncta* did not show linear relationship, as such their population could not be estimated.

(5) Length frequency curves suggested that there was no large recruitment of small prawn during the study period in case of *M. dobsoni, P. stylifera,* and there were heavy recruitment of small prawn during the latter part of the survey in case of *P. coromandelica, P. semisulcatus, P. indicus* and *P. cornuta.*

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TABLE 1

Total Member of Boats,, sampled Number of Boats, percentage of the Boats sampled, average effort per Boat, Coeficient of Variation of effort, Average catch per Boat, Caefficient of Variation of Catch (small and large added)

Date	*Total boats*	*Sampled No. of Boats*	*Percentage*	*Average effort per boat (minutes)*	*Coefficient of variation of effort*	*Average catch per boat (pounds)*	*Coefficient of variation of catch*
13.01.77	70	21	30.0	327.429	0.2698	35.3631	0.5983
14.01.77	79	25	31.6	308.320	0.2200	42.3000	0.6149
15.01.77	75	21	28.0	273.619	0.2865	36.0357	0.4056
17.01.77	79	26	32.9	272.192	0.2337	21.0769	0.4423
18.01.77	72	34	47.2	263.235	0.2878	10.3125	0.6454
19.01.77	68	20	29.4	285.200	0.2031	11.3125	0.6657
20.01.77	67	20	29.8	294.400	0.1682	18.7094	0.5717
21.01.77	70	23	32.8	287.696	0.2396	15.5054	0.6071
22.01.77	69	31	44.9	267.968	0.3288	16.4153	0.6387
24.01.77	50	24	48.0	307.375	0.1672	21.5990	0.5439
25.01.77	67	32	47.8	295.812	0.2302	33.5000	0.6833
26.01.77	60	20	33.3	289.950	0.2082	38.6188	0.4015
27.01.77	72	21	29.1	288.048	0.1607	26.2976	0.7342
28.01.77	76	25	32.9	271.320	0.3098	17.9525	0.6542
29.01.77	60	18	30.0	248.278	0.2851	13.4722	0.7669
31.01.77	46	30	65.2	340.433	0.1054	26.9750	0.5587
01.02.77	64	31	48.4	240.194	0.2795	22.1250	0.8080
02.02.77	68	22	32.4	259.682	0.3391	15.8542	0.4648
03.02.77	63	31	49.2	278.903	0.2193	14.6089	0.5615
04.02.77	66	14	21.2	270.968	0.2162	187.1786	0.3913
05.02.77	86	37	43.0	356.784	0.4143	370.8885	0.6144
07.02.77	86	39	45.0	218.026	0.2219	5.1204	0.7515
08.02.77	72	27	37.5	290.963	0.2236	56.6296	0.7923
09.02.77	64	18	28.1	326.389	0.1414	12.3330	0.7413
10.02.77	64	30	46.9	323.833	0.1873	11.0875	0.8340
11.02.77	54	27	50.0	286.704	0.2638	6.2350	0.7007
12.02.77	62	28	45.2	319.036	0.1852	11.7589	0.5295
14.02.77	67	39	58.2	327.872	0.2063	13.9455	0.5248
15.02.77	71	33	46.5	289.939	0.1903	10.8182	0.7034
16.02.77	56	26	46.4	270.615	0.2042	9.6923	0.5767
17.02.77	56	27	48.2	265.815	0.2417	5.6600	0.6539
18.02.77	52	25	48.1	286.000	0.1984	7.7400	0.6306
19.02.77	55	27	49.1	286.704	0.1025	8.0093	0.5720
21.02.77	51	22	43.1	329.227	0.1970	12.6648	0.4877
22.02.77	50	25	50.0	335.960	0.1940	14.6450	0.3508
23.02.77	52	25	48.1	329.040	0.2230	12.7750	0.4063
24.02.77	52	25	48.1	316.960	0.2040	15.6050	0.5595
25.02.77	52	23	44.2	301.696	0.2190	13.7663	0.5391
26.02.77	50	25	50.0	311.720	0.1820	9.5450	0.7585
28.02.77	51	25	49.0	319.400	0.2070	12.5500	0.5565
01.03.77	51	25	49.0	310.440	0.1380	15.4150	0.5908

TABLE 2

Daily Effort, Daily Catch, Catch per Hour of Effort C (*t*) and Accumulated Catch A (*t*)

Date	*Total Effort (Minutes)*	*M. dobsoni*			*Parap. stylifera and Parap. coromandelica*		
		Total Catch (Lbs.)	*C (t)*	*A (t)*	*Total Catch (Lbs.)*	*C (t)*	*A (t)*
13.1.77	22,395	1,551	4.155	0	60	0.161	0
14.1.77	24,382	2,177	5.357	1,151	127	0.312	60
15.1.77	20,579	1,747	5.094	3,728	515	1.502	187
17.1.77	21,613	937	2.601	5,475	303	0.841	702
18.1.77	19,209	166	0.518	6,412	222	0.693	1,005
19.1.77	19,682	527	1.606	6,578	22	0.067	1,227
20.1.77	19,724	560	1.704	7,105	530	1.612	1,249
21.1.77	20,139	545	1.624	7,665	315	0.938	1,779
22.1.77	18,640	429	1.381	8,210	442	1.423	2,094
24.1.77	15,378	513	2.002	8,639	22	0.086	2,536
25.1.77	19,747	1,664	5.056	9,152	102	0.310	2,558
26.1.77	17,397	1,583	5.460	10,816	300	1.035	2,660
27.1.77	20,856	908	2.612	12,399	139	0.400	2,960
28.1.77	21,047	1,022	2.914	13,307	77	0.220	3,099
29.1.77	15,142	299	1.185	14,329	104	0.412	3,176
31.1.77	14,694	952	3.887	14,628	133	0.543	3,280
1.2.77	15,447	743	2.886	15,580	104	0.404	3,413
2.2.77	17,994	521	1.737	16,323	17	0.057	3,517
3.2.77	17,681	609	2.067	16,844	30	0.102	3,534
4.2.77	18,116	5,388	17.845	17,453	219	0.725	3,564
5.2.77	31,698	32,643	61.789	17,970	163	0.308	3,783
7.2.77	18,750	641	2.051	18,487	73	0.234	3,946
8.2.77	20,966	3,178	9.095	19,004	216	0.618	4,019
9.2.77	20,889	301	0.865	19,521	169	0.485	4,235
10.2.77	20,939	93	0.266	19,822	82	0.235	4,404
11.2.77	15,809	11	0.042	19,915	56	0.212	4,486
12.2.77	19,801	29	0.088	19,926	37	0.112	4,542
14.2.77	21,922	253	0.692	19,955	40	0.110	4,579
15.2.77	20,586	32	0.093	20,208	119	0.347	4,619
16.2.77	15,164	47	0.186	20,240	127	0.502	4,738
17.2.77	14,856	19	0.077	20,287	63	0.254	4,865
18.2.77	15,014	2	0.008	20,306	90	0.360	4,928
19.2.77	15,636	47	0.180	20,308	63	0.242	5,018
21.2.77	16,904	48	0.170	20,355	22	0.078	5,081
22.2.77	16,796	51	0.182	20,403	122	0.436	5,103
23.2.77	17,110	82	0.288	20,454	197	0.691	5,225
24.2.77	16,482	82	0.298	20,536	15	0.055	5,422
25.2.77	15,677	272	1.041	20,618	92	0.352	5,437
26.2.77	15,714	161	0.615	20,890	16	0.061	5,529
28.2.77	16,275	160	0.590	21,051	33	0.122	5,545
1.3.77	15,832	117	0.443	21,211	44	0.167	5,578

TABLE 2 (*Contd.*)

Daily Effort, Daily Catch, Catch per Hour of Effort C(*t*) and Accumulated Catch A(*t*)

Date	*Total Effort (Minutes)*	*Parap. cornuta*			*P. monodon*			*P. semisulcatus*		
		Total Catch (Lbs.)	*C (t)*	*A (t)*	*Total Catch (Lbs.)*	*C (t)*	*A (t)*	*Total Catch (Lbs.)*	*C (t)*	*A (t)*
13.1.77	22,395	10	0.027	0	20	0.054	0	18	0.048	0
14.1.77	24,382	21	0.052	10	13	0.032	20	6	0.015	18
15.1.77	20,579	4	0.012	31	16	0.047	33	6	0.018	24
17.1.77	21,613	7	0.019	35	3	0.008	49	17	0.047	30
18.1.77	19,209	20	0.062	42	3	0.009	52	46	0.144	47
19.1.77	19,682	21	0.064	62	2	0.006	55	31	0.094	93
20.1.77	19,724	3	0.009	83	8	0.024	57	22	0.067	124
21.1.77	20,139	4	0.012	86	9	0.037	65	22	0.066	146
22.1.77	18,640	2	0.006	90	6	0.019	74	28	0.090	168
24.1.77	15,378	9	0.035	92	17	0.066	80	71	0.277	196
25.1.77	19,747	8	0.024	101	10	0.030	97	94	0.286	267
26.1.77	17,397	11	0.038	109	12	0.041	107	62	0.214	361
27.1.77	20,856	48	0.138	120	10	0.029	119	45	0.130	423
28.1.77	21,047	2	0.006	168	10	0.028	129	73	0.208	468
29.1.77	15,142	8	0.032	170	10	0.040	139	57	0.226	541
31.1.77	14,694	6	0.024	178	9	0.037	149	196	0.800	598
1.2.77	15,447	5	0.019	184	8	0.031	158	122	0.474	794
2.2.77	17,994	6	0.020	189	9	0.030	166	61	0.203	916
3.2.77	17,681	6	0.020	195	9	0.030	175	59	0.200	977
4.2.77	18,116	—	—	—	7	0.023	184	73	0.242	1,036
5.2.77	31,698	—	—	—	12	0.023	191	100	0.189	1,109
7.2.77	18,750	2	0.006	213	9	0.029	203	45	0.144	1,209
8.2.77	20,966	1	0.003	215	12	0.034	212	35	0.100	1,254
9.2.77	20,889	9	0.026	216	6	0.017	224	55	0.158	1,289
10.2.77	20,939	17	0.049	225	7	0.020	230	92	0.264	1,344
11.2.77	15,809	19	0.072	242	5	0.019	237	49	0.186	1,436
12.2.77	19,801	51	0.154	261	10	0.030	242	150	0.454	1,485
14.2.77	21,922	14	0.038	312	18	0.049	252	75	0.205	1,635
15.2.77	20,586	27	0.079	326	14	0.041	270	168	0.490	1,710
16.2.77	15,164	19	0.075	353	13	0.051	284	65	0.257	1,878
17.2.77	14,856	5	0.020	372	14	0.056	297	68	0.275	1,943
18.2.77	15,014	2	0.008	377	15	0.060	311	96	0.384	2,011
19.2.77	15,636	2	0.008	379	22	0.084	326	102	0.391	2,107
21.2.77	16,904	4	0.014	381	19	0.067	348	233	0.827	2,209
22.2.77	16,796	13	0.046	385	26	0.093	367	304	1.086	2,442
23.2.77	17,110	20	0.070	398	14	0.049	393	181	0.635	2,746
24.2.77	16,482	9	0.033	418	8	0.029	407	299	1.088	2,927
25.2.77	15,677	10	0.038	427	9	0.034	415	127	0.486	3,226
26.2.77	15,714	—	—	—	8	0.030	424	132	0.504	3,353
28.2.77	16,275	37	0.136	447	11	0.041	432	155	0.571	3,485
1.3.77	15,832	44	0.167	484	17	0.064	443	237	0.898	3,640

TABLE 2 (*Contd.*)

Daily Effort, Daily Catch, Catch per Hour of Effort C (*t*) and Accumulated Catch A (*t*)

Date	*Total Effort (Minutes)*	*P. indicus*			*Parap. uncta*			*M. monoceros*		
		Total Catch (Lbs.)	*C (t)*	*A (t)*	*Total Catch (Lbs.)*	*C (t)*	*A (t)*	*Total Catch (Lbs.)*	*C (t)*	*A (t)*
13.1.77	22,395	562	1.506	0	152	0.407	0	97	0.260	0
14.1.77	24,382	464	1.142	562	326	0.802	152	207	0.509	97
15.1.77	20,579	304	0.886	1,026	36	0.105	478	76	0.222	304
17.1.77	21,613	198	0.550	1,330	62	0.172	514	131	0.364	380
18.1.77	19,209	126	0.394	1,528	23	0.072	576	39	0.122	511
19.1.77	19,682	106	0.323	1,654	19	0.058	599	41	0.125	550
20.1.77	19,724	89	0.271	1,760	42	0.128	618	—	—	—
21.1.77	20,139	99	0.295	1,849	35	0.104	660	35	0.104	591
22.1.77	18,640	137	0.441	1,948	36	0.116	695	48	0.154	626
24.1.77	15,378	215	0.839	2,085	45	0.176	731	92	0.359	674
25.1.77	19,747	249	0.737	2,300	—	—	—	67	0.204	766
26.1.77	17,397	184	0.635	2,549	49	0.169	776	109	0.376	833
27.1.77	20,856	78	0.224	2,733	218	0.627	825	484	1.392	942
28.1.77	21,047	125	0.356	2,811	10	0.028	1,043	40	0.114	1,426
29.1.77	15,142	117	0.464	2,936	69	0.273	1,053	140	0.555	1,466
31.1.77	14,694	142	0.580	3,053	51	0.208	1,122	—	—	—
1.2.77	15,447	173	0.672	3,195	40	0.155	1,173	—	—	—
2.2.77	17,994	172	0.574	3,368	13	0.043	1,213	16	0.053	1,606
3.2.77	17,681	173	0.587	3,540	31	0.105	1,226	—	—	—
4.2.77	18,116	143	0.474	3,713	42	0.139	1,257	—	—	—
5.2.77	31,698	118	0.223	3,856	20	0.038	1,299	—	—	—
7.2.77	18,750	152	0.486	3,974	26	0.083	1,319	18	0.058	1,622
8.2.77	20,966	463	1.325	4,126	112	0.320	1,345	11	0.032	1,640
9.2.77	20,889	130	0.373	4,589	—	—	—	82	0.236	1,651
10.2.77	20,939	363	1.040	4,719	23	0.066	1,457	22	0.063	1,733
11.2.77	15,809	172	0.653	5,082	29	0.110	1,480	69	0.262	1,755
12.2.77	19,801	243	0.736	5,254	77	0.233	1,509	122	0.370	1,824
14.2.77	21,922	444	1.215	5,497	48	0.131	1,586	43	0.118	1,946
15.2.77	20,586	329	0.959	5,941	37	0.108	1,634	33	0.096	1,989
16.2.77	15,164	245	0.969	6,270	2	0.008	1,671	11	0.044	2,022
17.2.77	14,856	192	0.775	6,515	15	0.061	1,673	—	—	—
18.2.77	15,014	173	0.691	6,707	1	0.004	1,688	20	0.080	2,033
19.2.77	15,636	166	0.637	6,880	10	0.038	1,689	14	0.054	2,053
21.2.77	16,904	300	1.065	7,046	6	0.021	1,699	5	0.018	2,067
22.2.77	16,796	193	0.689	7,346	7	0.025	1,705	15	0.054	2,072
23.2.77	17,110	131	0.459	7,539	11	0.039	1,712	26	0.091	2,087
24.2.77	16,482	255	0.928	7,670	65	0.237	1,723	67	0.244	2,113
25.2.77	15,677	180	0.689	7,925	—	—	—	23	0.088	2,180
26.2.77	15,714	150	0.573	8,105	0	0	1,788	37	0.141	2,203
28.2.77	16,275	222	0.818	8,255	4	0.015	1,788	12	0.044	2,240
1.3.77	15,832	258	0.978	8,477	15	0.057	1,792	52	0.197	2,252

TABLE 3

Test of linearity (Dixon and Massey 1957, Introduction to Statistical Analysis, Page 197), Values to calculate 'F'

	M. dobsoni			*P. stylifera and P. coromandelica*			*P. coruuta*			*P. indicus*		
	Sum of Squares	*d.f.*	*Mean Squares*	*Sum of Squares*	*d.f.*	*Mean Squares*	*Sum of Squares*	*d.f.*	*Mean Squares*	*Sum of Squares*	*d.f.*	*Mean Squares*
Within groups	14.779	26	0.56842	3.645	29	0.12569	0.0101	13	0.00078	0.9283	24	0.03868
Regression	76.289	1	—	1.539	1	—	0.0014	1	—	0.1102	1	—
About Regression	11.160	9	1.24000	1.055	10	0.10550	0.0067	6	0.00112	2.6869	15	0.17913
Total	87.449	10		2.594	11		0.0081	7		2.7971	16	

TABLE 3 (*Contd.*)

Test of linearity (Dixon and Massey 1957, Introduction to Statistical Analysis, Page 197), Values to calculate 'F'

	P. semisulcatus			*P. monodon*			*P. uncta*			*M. monoceros*		
	Sum of Squares	*d.f.*	*Mean Squares*	*Sum of Squares*	*d.f.*	*Mean Squares*	*Sum of Squares*	*d.f.*	*Mean Squares*	*Sum of Squares*	*d.f.*	*Mean Squares*
Within groups	0.4347	23	0.01890	0.0029	23	0.00013	0.127	23	0.00552	0.233	19	0.01226
Regression	1.5956	1	—	0.0029	1	—	0.272	1	—	0.268	1	—
About Regression	1.1336	16	0.07085	0.0090	16	0.00056	0.614	13	0.04723	1.563	13	0.12023
Total	2.7292	17		0.0119	17		0.886	14		1.831	14	

TABLE 4

Breakdown figures of Catch for the Period 13.1.77 to 1.3.77 for each Species of Prawn and Total Catch of fish for the same period

Scientific Name	*Vernacular Name*	*Number of Pieces Per Pound*										*Total Pounds*	*Per-cent*
		1–10	10–34	35–54	55–149	150–299	300–449	450–600	>600	>2,000	>3,000		
1 Metapenaeus dobsoni	Mal-issa	—	—	—	43968.9	14982.0	2156.8	—	—	—	—	61107.7	71.63
2 Penaeus indicus	Kiri-issa	663.4	7842.4	—	16.8	215.5	—	—	—	—	—	8738.1	10.24
3 Parap. stylifera 4 Parap. coromandelica	Kakulu-issa	—	—	—	1374.0	3950.6	—	265.6	31.3	—	—	5621.5	6.59
5 Penaeus semisulcatus	Kurutu-issa(Tiger)	607.4	2833.2	—	348.5	88.9	—	—	—	—	—	3878.0	4.55
6 Metapenaeus monoceros	Thandu-issa Rathu-issa	—	—	633.7	1669.0	—	—	—	—	—	—	2302.7	2.70
7 Parap. uncta	Gal-issa	—	—	14.3	1775.0	—	17.6	—	—	—	—	1806.9	2.12
8 Parap-cornuta	Gal-issa	—	—	—	—	—	426	102	—	—	—	528.0	0.62
9 Penaeus monodon	Karavandu-issa (Tiger)	453.5	6.2	—	—	—	—	—	—	—	—	459.7	0.54
10 Metapenaeus mutatus	Rathu-issa Thandu-issa	—	—	151.2	18.3	—	—	—	—	—	—	169.5	0.20
11 Metapenaeus ensis	do.	—	—	70.1	8.5	—	—	—	—	—	—	78.6	0.09
12 Metapenaeopsis hilarulus	do.	—	—	—	—	—	31.9	—	—	—	—	31.9	0.04
13 Metapenaeus burkenrodi	do.	—	—	—	5.6	6.8	—	—	—	—	—	12.4	0.01
14 Metapenaeus elegans	do.	—	—	—	—	1.2	—	—	—	—	—	1.2	0.001
15 Unidentified immature prawns	Kooni-issa	—	—	—	—	—	—	—	—	—	264.0	264.0	0.31
16 Unidentified 17 Metapenaeus species	Rathu-issa Thandu-issa	—	—	4.3	134.8	41.2	—	—	—	—	—	180.3	0.21
18 Trachypeneus species	—	—	—	—	—	9.9	—	22.3	3.8	—	—	36.0	0.04
19 Caridian species	Bandi-issa	—	—	—	—	—	—	—	88.3	—	—	88.3	0.10
20 Parapeneopsis species	—	—	—	—	—	—	—	—	—	0.6	—	0.6	0.0007
												85305.4	99.991

Fish — 103,139 Pounds (Silver biddy, jew fish, estuarine purch, cat fish, small skate, squid, sea crab, Tongue-soles, etc.).